Teaching Introductory Computer Science Classes by Utilizing Video Games

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Outline

Outline

Why We Care

- Teaching is difficult
- 40% of students leave in introductory courses
- Alternate methods

ACM Guidelines

- Baseline
- Basic problem solving
- Syntax
- Recursion or non-recursive iteration

ACM Guidelines (cont.)

- No concensus
  - Different devices
- Vague guidelines
- Video games

Difficulties of Recursion

```
public void R1(int x){
  if (x > 0){
    System.out.print(x);
    R1(x - 1);
  }
}
```

Modified from [5]

R1(3) prints 321

```
public void R2(int x){
  if (x > 0){
    R2(x - 1);
    System.out.print(x);
  }
}
```

Modified from [5]

R2(3) prints 123

Difficulties of Recursion (cont.)

```
public void I1(int x){
   for(int i = x; i > 0; i--){
      System.out.print(i);
   }
}
```

I1(3) prints 321

Why Video Games

- Inherent learning
- Motivating
- Computer science style thinking

Outline

Designing an Educational Game

- Still needs to be a fun game
- Learning topic must be incorporated
- Two guidelines

Successful Game Guidelines

- Short, medium, and long-term goals
- Decision-making
- Immediate and specific feedback
- Complex reward system
- Long tasks are usually broken into shorter ones
- Master a specific task before progressing
- Multiple correct solutions, obviously wrong methods

Applied Behavior Analysis (ABA)

- Related to immediate and specific feedback
- ABA basics
- Issues with ABA

ABA Guidelines

- Three Steps
  - Defining/measuring desired behavior
  - Recording/analyzing behavior
  - Feedback
- Adaptation

Outline

Circuitry

- Goal is to reach the exit
- Solve logic gates to progress

Solving Problems

- Toggle inputs
- Constant feedback on correctness

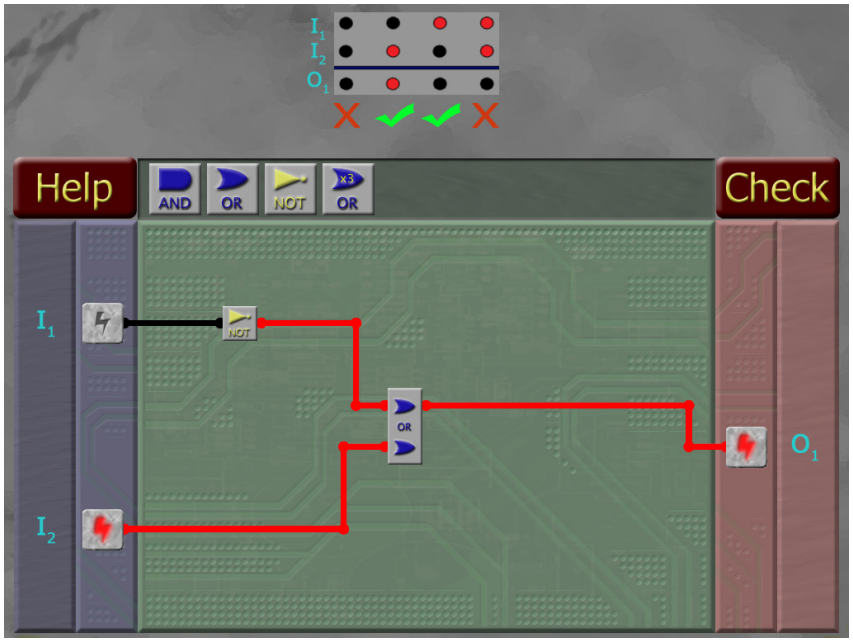


Image from [4]

Pilot Test

- 9 from target group
- Pre-test
  - Eight got 0%
  - One got 100%
  - 0.22/2.00 mean score
- Playing the game
  - 75 minute cap of play
  - Enjoyable
- Post-test
  - Four still got 0%
  - 0.72/2.00 mean score

Future Work

- Larger Study
- Add a plot (for motivation)
- More variety
- Tutorial
- Context-sensitive tips

Circuitry Conclusions

- Successful Games
  - Long Term Goal
  - Feedback
  - Difficulty progression
- ABA
  - Knew what behavior was desired
  - Better feedback (future work)

Recursion with Cargo-Bot

- Adapted commerical game
- Primative language
- Goal is to transform the start state to the end state

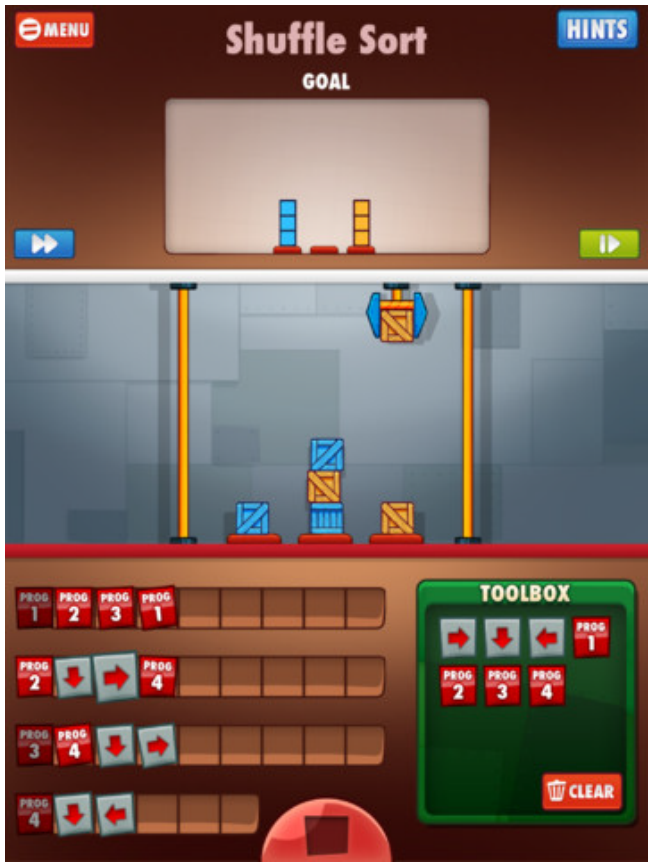


Image from [5]

Why Cargo-Bot?

Exemplifies recursion

- Self-referencing
- has a base case
- Each step progresses to base case

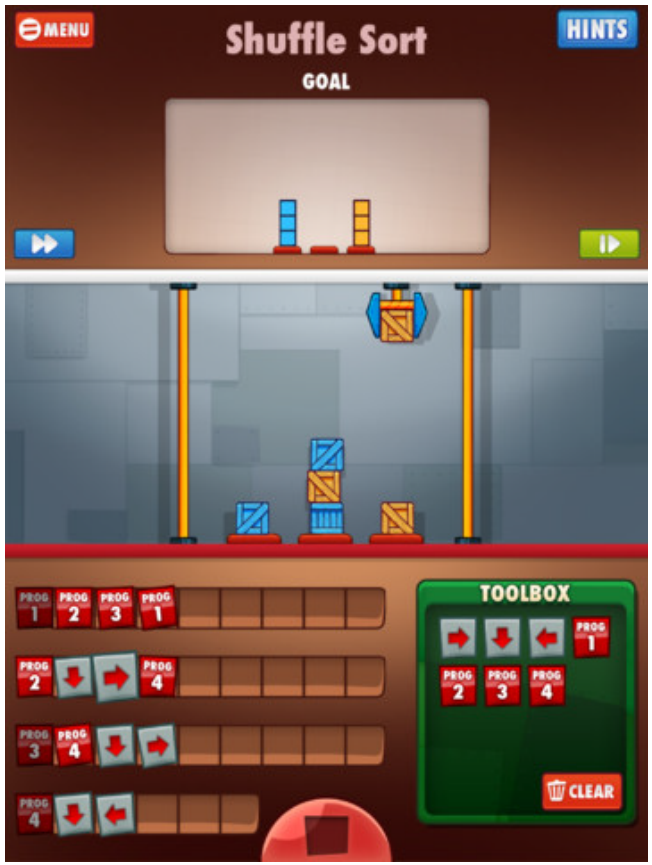


Image from [5]

Test Structure

Cargo-Bot

Control Group

- Day 1
  - 20 Minute pre-test
  - 50 Minute lecture
  - 15 Minute mid-test
- Day 2
  - 90 Minute playing Cargo-Bot
  - 20 Minute post-test

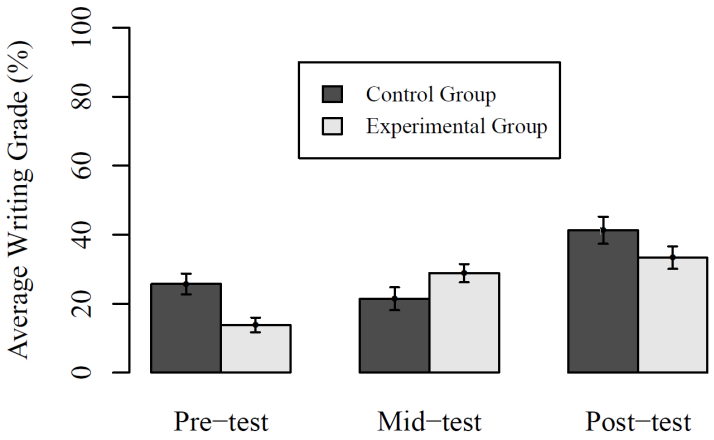
Experimental Group

- Day 1
  - 20 Minute pre-test
  - 90 Minute playing Cargo-Bot
- Day 2
  - 15 Minute mid-test
  - 50 Minute lecture
  - 20 Minute post-test

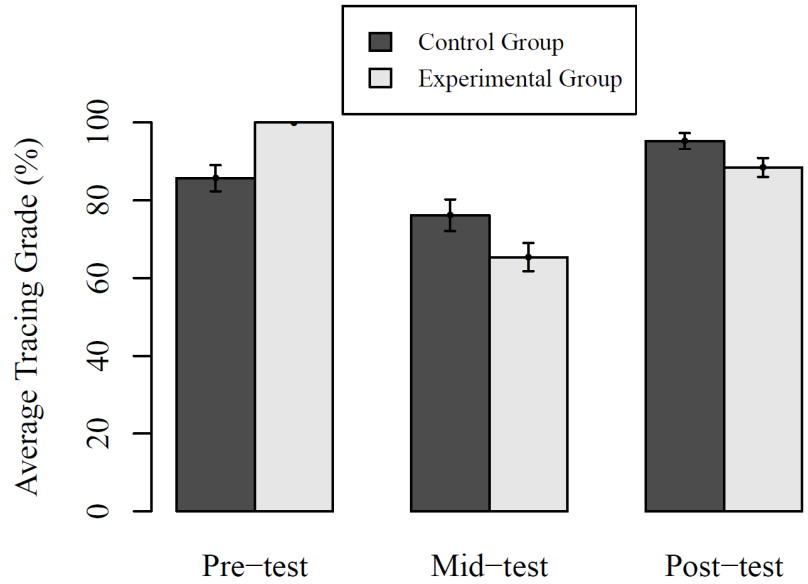
Test Structure (cont.)

- Lecture
  - Recursion
  - Program Stack
  - Recursion examples
- Tests
  - Writing a recursive function
  - Understanding an existing recursive function

Test Results



Scores for Writing Recursive Functions, from [5]



Scores for Reading Recursive Functions, from [5]

Future Work

- Change the way the game carries out procedures

Cargo-Bot Conclusions

- Successful Games
  - Feedback
  - Went against difficulty progression
- ABA
  - Feedback

Recursion with EleMental

Three Levels

- Level 1
  - “Hello World” program
  - Depth-first search (DFS) through a tree manually
- Level 2
  - Scaffolding code
  - Write left-hand side of DFS
- Level 3
  - Write both sides
  - Instruction on program stack
  - Telephone example

```
public void depthFirstSearch(Node node) {
    Thought.moveTo(node);
    // Check for Base Case
    if ((node.returnRight() == null)
        && (node.returnLeft() == null)) {
        return;
    } else { // Recursive calls
        // Travel to node's right child
        if (node.returnRight() != null) {
            depthFirstSearch(node.returnRight());
            Thought.moveTo(node);
        }
        // Travel to node's left child
        if ([YOUR_CODE] != null) {
            [YOUR_CODE]
        }
    }
    return;
}
```

Test Structure

- Pre-test
- Playtime (playtime)
- Post-test
- 43 participants (all taking/took UNCC's "Data Structures and Algorithms" class)
- 16 took pre-test

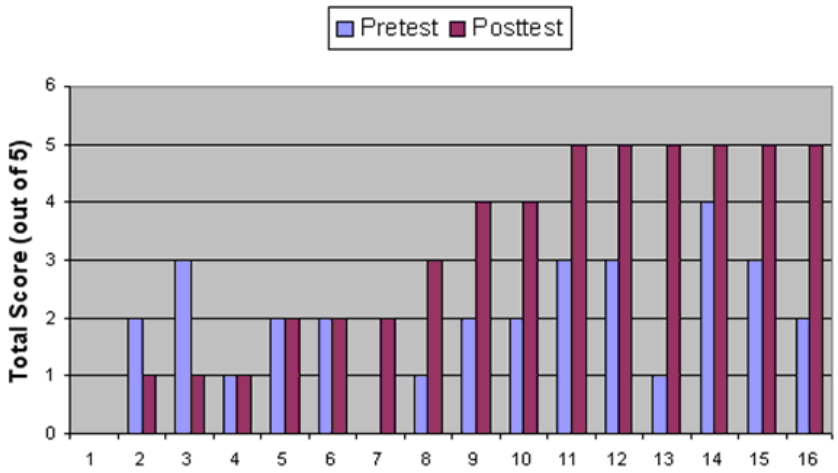


Image from [1]

Future Work

- Show advantages of recursion (replace the “Hello World” part)
- Show what compilable code does
- Improve the telephone metaphor
- Experience point system

EleMental Conclusions

- Successful Games
  - Feedback
  - Difficulty progression
  - Went against having multiple correct solutions
- ABA
  - Desired behavior
  - Feedback (future work)
- Other
  - No significant correlation between time and score

Outline

Overall Conclusions

- None of the examples exemplified step 2 of ABA
- None of the examples had adaptable steps 1-3
- Still unknown if video games have a place

Overall Future Work

- Better research
- Larger sample sizes
- Adhere to the two guidelines

Questions?

References

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